EXPLORATORY ANALYSIS OF DELAY DISCOUNTING AND COGNITIVE-AFFECTIVE REGULATION MEASURES IN COCAINE USERS

by

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Dedication

For my parents. Thank you for your ever-present support.

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ABSTRACT

EXPLORATORY ANALYSIS OF DELAY DISCOUNTING AND COGNITIVE-AFFECTIVE REGULATION MEASURES IN COCAINE USERS

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Research investigating addiction across populations suggests that identifying high-risk behavioral factors within a population may help identify key areas to target during treatment. Delay discounting, the measure of the preference for smaller, sooner rewards over larger rewards after a longer delay, has been shown to be a robust predictor of relapse risk, treatment compliance, and abstinence duration in addicted populations. Previous work suggests that individuals exhibiting higher rates of delayed reward discounting are more likely to develop a substance use disorder, and that the continual abuse of substances perpetuates an increase in impulsive decision-making over time, contributing to the cyclic nature of chronic substance use. In addition to behavioral measures, self-report measures assessing high-risk cognitive-affective factors (e.g., distress tolerance, emotion regulation) have also proven to be robust predictors of treatment outcomes. Given the observed correspondence between heightened impulsivity, cognitive-affective regulation, and substance abuse, understanding variables that may interact with impulsive behavior is a promising path towards more effective treatment outcomes. This project had three aims: to compare delay discounting modelling techniques (AUC, Mazur's *k*, AUClog, and log-*k*) in a cocaine-abusing sample, to analyze three cognitive-affective regulation measures (AIS, DERS, and DTS) for potential latent factors, and to assess the relationships between these cognitive-affective measures and delay discounting models. Results of the delay discounting modelling comparing AUC, AUClog, Mazur's *k*, and log-*k* methods to AIS, DTS, and DERS scores yielded no significant relationships, though non-significant trends were consistent with previous literature. An exploratory factor analysis yielded a final three factor solution, with factors corresponding to the DTS, the DERS, and the AIS, respectively. Though delay discounting models and cognitive-affective regulation have been linked to similar treatment outcomes, an exploratory analysis investigating the relationship between these variables suggests no direct relationship between delay discounting and emotion regulation, distress tolerance, or psychological avoidance/inflexibility.

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CHAPTER 1

INTRODUCTION

Scope of the Problem

Psychostimulant substance use disorders pose significant risks to health, economic opportunity, and quality of life. In 2017, an estimated 966,000 Americans struggled with cocaine use, and approximately 637,000 reported receiving treatment (Substance Abuse and Mental Health Services Administration, 2018). Though over half of estimated substance users report receiving treatment every year, the rates of cocaine use disorder in the United States have remained relatively stable for the past decade. This stable pattern of continued substance use suggests weaknesses in current methods of substance abuse treatment, which, in turn, suggests weaknesses in the current body of scientific literature surrounding the nature of chronic substance use. Unlike other substance use disorders, there is currently no FDA approved pharmacotherapy for cocaine use disorder, and standard psychotherapeutic treatment has been only moderately effective (Sayegh et al., 2017). Cocaine addiction is comprised of a complex blend of environmental, cognitive, affective, behavioral, and neurobiological factors. In order to create targeted approaches and improve the likelihood for success of psychotherapeutic treatments, it is necessary to parse out specific variables associated with poor treatment outcomes. To this end, this study sought to analyze the relationships between delay discounting and cognitive-affective regulation measures, both robust predictors of treatment outcomes, in order to better understand the complex nature of cocaine use disorder.

Purpose of the Study

Preclinical research has found heterogeneity of behaviors and brain activity between animals addicted to cocaine (Flagel et al., 2008; Saunders & Robinson, 2010; Yager & Robinson, 2010). These findings demonstrate that among addicted individuals, neurobiological responses to the same addictive stimuli can produce distinctive clusters of characteristics within the same population. Research investigating addiction across populations suggests that identifying high-risk behavioral factors within a population may help identify key areas to target during treatment (Bickel & Marsch, 2001; Engelmann et al., 2016; MacKillop et al., 2011; Versace et al., 2016). One such behavioral measure commonly used in substance use research is delay discounting. Delay discounting is a validated measure of impulsivity that has been widely used as a predictor of high-risk variables including treatment compliance (Stevens et al., 2014), duration of abstinence (Stanger et al., 2012), and relapse (Stanger et al., 2012; Stotts et al., 2015), as well as drug use frequency (Kollins, 2003) and severity (Stotts et al., 2015). Given the strong observed relationship between heightened impulsivity and substance abuse, understanding variables that may impact impulsive behavior is a promising path towards more effective treatment outcomes.

In addition to behavioral measures, self-report measures assessing high-risk cognitive-affective variables have also proven to be a robust predictor of treatment outcomes (Banducci et al., 2016; Tull et al., 2018; Vujanovic et al., 2018). Psychological avoidance (i.e., the tendency of an individual to reduce or avoid internal distressing thoughts and feelings) and inflexibility (i.e., the inability to be conscious and involved in the present moment while maintaining behavior in accordance with personal values) are cognitive-affective measures specific to Acceptance and Commitment Therapy (ACT), a derivative of Cognitive-Behavioral Therapy and a promising psychotherapeutic modality for addiction treatment. Research examining the clinical utility of ACT in addiction treatment suggests that avoidance and inflexibility may play a role in substance use treatment outcomes (Farris et al., 2014; 2015; Minami et al., 2015), and furthermore, that therapy targeting these domains may have a potentially moderating effect on delay discounting (Stotts et al., 2015), comparable to the effects of therapeutic techniques addressing emotion regulation and distress tolerance (Bornovalova, et al., 2011). Due to this potentially moderating effect on a high-risk variable, investigating the relationship between delay discounting and ACT-specific cognitive-affective measures could prove clinically meaningful in treating cocaine use disorder.

CHAPTER 2

IMPULSIVITY AND AFFECTIVE REGULATION

Impulsive Behavior

Dimensions of Impulsivity

Impulsivity is considered a multi-faceted construct, with the cognitive/behavioral literature surrounding this topic broadly categorizing three main groups: personality trait, behavioral inhibition, and delayed reward sensitivity. All three categories of impulsive behavior have been widely explored within the scope of addiction research (Bickel & Marsch, 2001; Ding et al., 2014; Farris et al., 2014; 2015; Goodman, 2008; Li et al., 2013; Minami et al., 2015) and play a role in understanding the onset and perpetuation of addictions. In particular, delay discounting tasks have been utilized in addiction research across substances, from tobacco (Bickel et al., 1999) and alcohol (Bidwell et al., 2013) to psychostimulants (Coffey et al., 2003; Heil et al., 2006; Stotts et al., 2015), demonstrating that delay discounting serves as a robust and consistent behavioral proxy for impulsivity, irrespective of substance of choice.

Impulsivity as a personality trait most often refers to scoring on self-report measures that broadly assess a combination of factors, including cue sensitivity, delayed reward sensitivity, behavioral inhibition, novelty seeking, and propensity towards risky judgements and decisions. Two of the most commonly used measures of personality trait impulsivity are the Barret Impulsiveness Scale (BIS; Patton et al., 1995), and the Urgency, Premeditation, Perseverance, Sensation Seeking, Positive Urgency, Impulsive Behavior Scale (UPPSP; Lynam et al., 2006). These self-report measures assess a broad range of behaviors associated with disadvantageous judgement and decision making and are routinely applied in substance abuse research (Stevens et al., 2014; Stotts et al., 2015; Vujanovic et al., 2018). Behavioral inhibition is defined as an individual's ability to inhibit instigated prepotent responses (Fillmore, 2003). Cued go no-go or stop-signal reaction tasks measure behavioral inhibition as the latency between the stop-cue and the response, with higher latencies associated with poorer inhibitory control. These tasks serve as laboratory models of an individual's ability to suppress prepotencies and respond correctly to stop cues (Fillmore et al., 2006). Findings using stop-go tasks in conjunction with psychostimulants have yielded mixed results, with some studies showing a hyperbolic increase in cognitive performance until a threshold is reached (Fillmore et al., 2006; Iliera & Farah, 2013). Given the lack of consistency between inhibition specific task studies administering different drugs, further research utilizing inhibitory control tasks is needed, and characteristics of impulsivity assessed either through personality trait measures or through delay discounting tasks may currently be better suited for identifying clinically-relevant patterns in impulsivity across the spectrum of addictive disorders.

Delay Discounting

Delay discounting is a reliable measure of the preference for smaller, sooner rewards over larger, later rewards (Odum, 2011). Examples of this principle in a natural environment would be a preference for eating immediately-rewarding high-calorie foods instead of abstaining for the delayed reward of improved health, or choosing to play a video game for the immediate pleasure rather than studying to receive the delayed reward of good grades. Behavioral analysts consider the smaller, sooner reward to be the "impulsive" choice, and the larger, later reward to be the "self-controlled" choice, and a representation of an individual's subjective rate of reward devaluation over time. In both human and non-human animal experiments, immediate consequences (positive or negative) have been shown to influence the rate at which behavior occurs more so than delayed rewards, and a preference for immediate rewards over delayed rewards has been demonstrated (Chung & Hernstein, 1967; Lattal, 2010). In human laboratory studies, delay discounting has traditionally been analyzed using the same type of reward for both the shorter and longer delays and has most often utilized money as the standard reward. During a delay discounting task, participants are given a series of questions in which they are asked to choose between either receiving a specified smaller amount of money sooner or a specified larger amount of money later. The point at which there is a 50% chance that the participant will choose either option is referred to as the indifference point, or the point at which both rewards hold approximately equal subjective value to the individual (Odum, 2011). More recent work examining trends in delay discounting within addicted populations has begun to relate rates of standardized discounting using money-to-money comparison tasks as well as drug-to-money tasks. These findings suggest that rates of delayed reward sensitivity for addicted populations are not only steeper compared to controls using money-to-money comparison tasks but also that rates of discounting are even steeper in these populations when the smaller sooner reward presented is the drug of choice (Yoon et al., 2018).

Delay Discounting and Addiction

The connection between naturally impulsive behavior and substance use is well evidenced, but previous literature investigating the directionality of this trend suggests that long-term substance use may additionally increase the rate of delay discounting (Mendez et al., 2010; Perry et al., 2005; Simon et al., 2007). Rates of delay discounting in cocaine-abstinent individuals may remain comparable to active cocaine-using individuals, with both abstinent and active users demonstrating a significantly steeper rate of reward discounting than matched healthy controls (Heil et al., 2006). These findings suggest that individuals who are less sensitive to delayed rewards are more likely to develop a substance use disorder, and the continual abuse of substances perpetuates an increase in impulsive decision-making over time, contributing to the cyclic nature of chronic substance use.

Though delay discounting has been evaluated in diverse populations, including behaviors such as binge-eating, internet addiction, and tobacco use, the application of these tasks to psychostimulant addicted samples is relatively recent (Stotts et al., 2015; Washio et al., 2011; Yoon et al., 2017; Yoon et al., 2018). Within the scope of addiction research, experimental delay discounting tasks have primarily been conducted with cigarette smokers (Bickel & Marsch, 2001; MacKillop et al., 2011; Reynolds, 2006), though the reliability of prediction and consistency between addiction populations suggests that continued exploration of the relationships between delay discounting rates and other clinically relevant measures may support the use of delay discounting tasks as a fast, inexpensive method of assessing the risks of negative outcomes, irrespective of drug of choice, at an individual level at the onset of treatment (Bickel et al., 2014a;2014b; Stevens et al., 2014). For example, delay discounting rates may predict abstinence duration for cocaine users undergoing contingency management-based treatment (Washio et al., 2011), a type of behavioral therapy in which individuals are rewarded for drug abstinence and currently the most widely successful method for treating substance use disorders (Prendergast et al., 2006). The authors reported a significant difference in abstinence duration in the high-magnitude contingency management group for steep discounters, but not in the low-magnitude contingency management group (Washio et al., 2011). Given the established relationship between steep rates of delay discounting and poor treatment outcomes among substance abusers (Mendez et al., 2010; Perry et al., 2005; Simon et al., 2007; Stotts et al., 2015), delay discounting may be a useful tool for assessing the efficacy of treatment techniques.

To maximize the effectiveness of delay discounting as an assessment tool, it is necessary to choose the most appropriate method for modelling discounting rates for a given population. One of the greatest strengths of a popular modelling technique, Area-Under-the-Curve (AUC), is the ease of use in secondary statistical analyses based on the assumption that it follows a normal distribution (Odum, 2011). However, irrespective of drug of choice, substance abusing populations have consistently demonstrated particularly steep rates of delay discounting (Bickel & Marsch, 2001; Heil et al., 2006; MacKillop et al., 2011; Yoon et al., 2017; Yoon 2018), resulting in data with notably highly skewed distributions. Several groups have found AUC to be disproportionately influenced by indifference points at longer delays, which may make this method less effective when creating models for populations expected to demonstrate steeper rates of delay discounting, and have recommended the use of alternative models such as AUC log and Mazur's k (Borges et al., 2016; Yoon et al., 2017; Yoon et al., 2018). These findings suggest that when modelling delay discounting rates in a substance abusing population, it may be more prudent to select models that are more sensitive to indifference points at shorter delays, rather than the more popular AUC method. Continued study of the applicability, methodology, and trends pertaining to delay discounting among cocaine users may provide further support for the clinical utility of these tasks when treating psychostimulant substance use disorders.

Mechanisms of Impulsivity

Understanding mechanisms of impulsivity, as well as the many ways impulsive behaviors interact with addiction, is a vital part of identifying patterns that contribute to the improvement of treatments for these diseases. An influential theory of addiction assigns a central role to the attachment of incentive salience to cues, such that cues associated with drug use, such as drug paraphernalia, become motivationally relevant, and induce cravings that prompt drug use (Robinson & Berridge, 1993). Individuals who tend to demonstrate at least one expression of highly impulsive behavior may be more susceptible to forming cue-induced addictive behaviors (Gamito et al., 2014; Mogg et al., 2004).

Further, psychostimulant addiction is often accompanied by anhedonia, or the diminished response to natural pleasurable/rewarding stimuli (Volkow et al., 2011; Zhang et al., 2016). Deficits in pleasure and reward-sensitivity are thought to contribute to impulsive behaviors observed in chemically dependent individuals (Leventhal et al., 2010). This decreasing strength of rewards not related to drug use may make it more difficult for recovering addicts to sustain abstinence. These findings suggest that cognitive-affective regulation strategies addressing cue-induced behaviors may be meaningfully related to the ability to inhibit the effects of cue-induced cravings. As such, therapeutic techniques specifically addressing interactions between impulsivity and different domains of cognitive-affective regulation (e.g., distress tolerance and emotion regulation subdomains) may be uniquely positioned to target cue-induced relapse risk.

Affective Regulation

Affective Regulation and Addiction

Affective (or emotion) regulation can broadly be described as the conscious and unconscious processes humans use to modify our emotional states to achieve a specific outcome (Aldao et al., 2010). Purposefully engaging in relaxation techniques, such as breathing exercises, or responding to a distressing stimulus by involuntarily crying to mitigate symptoms of stress would be examples of affective regulation processes. Affective regulation strategies such as binge eating, gambling, and drug consumption are considered maladaptive regulation behaviors that sacrifice long-term benefits (e.g., health, opportunities, and relationships) for the short-term benefits of pleasure and/or avoidance of distress (Estévez et al., 2017; Griffiths, 2005). Several prominent theories of addiction relate back to substance abuse across populations as a maladaptive method of emotion regulation (Curtain et al., 2006; Minami et al., 2015; Volkow et al., 2011), as substance abuse has the potential to be powerfully negatively reinforced by alleviating stress or pain (Farris et al., 2015).

Affective regulation is a broad area of study, encompassing many dimensions including distress tolerance, cognitive regulation, experiential avoidance, and psychological inflexibility (Aldao et al., 2010). Further, dimensions of affective regulation can be broken down into sub-domains (e.g., physical versus emotional distress tolerance, sensation versus cognitive experiential avoidance; Farris et al., 2015; Zvolensky et al., 2010). Research across addicted populations supports that dimensions of affective regulation underly many of the processes that contribute to the onset and perpetuation of addictions. Due to the complex nature of addictions, it is of benefit to narrow the scope of study and analyze mechanisms of specific affective regulation domains (e.g., distress tolerance, experiential avoidance) in order to best inform targeted clinical approaches to treatment.

Distress Tolerance

Distress tolerance refers to the ability of an individual to tolerate uncomfortable thoughts, feelings, and physical sensations (Vujanovic et al., 2018). Distress tolerance can be subcategorized into two distinct domains: the individual's perception of their ability to withstand physical or emotional distress, and the individual's actual behavior when presented with distress (Zvolensky et al., 2010). In a controlled laboratory setting, distress tolerance can be measured either using self-report measures or through behavioral tasks (e.g., cold pressor task, breath task). Self-report measures capture the perceived ability of an individual to adaptively respond to distressing thoughts, feelings, and physical sensations, whereas behavioral tasks measure the latency between the onset of an uncomfortable stimulus (e.g., freezing water, held breath) and voluntary disengagement from that stimulus. The duration is calculated starting from the time the participant first reports feeling discomfort from the stimulus and ends at the point at which the participant chooses to disengage from the stimulus. While distress tolerance does overlap to a certain extent with other cognitive-affective regulation processes, research supports distress tolerance as its own distinct protective process (Leyro et al., 2010). Subdomains of distress tolerance, however, are presently still not well understood. Some models have proposed the existence of a hierarchical structure for distress tolerance, with several subdomains making up a higher-order experiential distress intolerance factor. Further work has investigated the possible existence of latent factors within domains of distress tolerance and affective regulation that may more appropriately explain the apparent overlapping components of these variables (Bernstein et al., 2009).

A growing body of literature surrounding the role of distress tolerance in addiction has demonstrated a relationship between this construct and treatment outcomes that is similar to those predicted by delayed reward sensitivity tasks (Kaiser et al., 2012; Kozak & Fought, 2011; Zvolensky et al., 2010). From a neurobehavioral perspective, distress tolerance has been described as a combination of the ability to not respond to negative reinforcement (e.g., relief from an unpleasant thought, feeling, or sensation), and the propensity towards selecting "self-controlled" choices rather than immediate gratification (e.g., delayed reward sensitivity; Trafton & Gifford, 2011). Given the similarities in predicted high-risk factors associated with these variables, as well as the conceptual overlap between constructs, it is possible that delayed reward sensitivity and distress tolerance may be related processes involved in forming and sustaining addictions. Reduced cue-sensitivity to non-drug related stimuli (e.g., the more temporally distant non-drug related rewards associated with abstinence such as improved health or relationships) may reduce distress tolerance over time, contributing to the perpetuation of cyclic reinforcement in addiction. Further examination of the composites of higher-order distress tolerance may yield more insight into this process.

Avoidance and Inflexibility

Experiential avoidance and psychological inflexibility are mechanisms that describe a regulatory process in which individuals attempt to avoid or mentally disengage from aversive internal stimuli (e.g., painful thoughts, feelings, cognitive response to physical sensations, etc.; Hayes et al., 2004). Experiential avoidance is defined by the drive to escape aversive internal stimuli, and psychological inflexibility refers to the rigid adherence to innate psychological responses instead of value-driven responses.

Current substance use treatment research has already demonstrated that some cognitive-affective measures, such as emotion regulation and emotional distress tolerance, may be meaningful indicators of an individual's ability to successfully complete treatment (Bornovalova et al., 2011; Daughters et al., 2005). These cognitive-affective measures assess the capacity to tolerate distressing thoughts and feelings, as well as the ability to adaptively process strong feelings. On the surface, experiential avoidance and psychological inflexibility appear very similar to dimensions of distress tolerance and emotion regulation (Farris et al., 2015; Hayes et al., 2004; Stotts et al., 2015;), and some overlap may exist between measures of these constructs. Comparing an avoidance and inflexibility measure, the Avoidance and Inflexibility Scale (AIS), to similar cognitive-affective measures, (i.e., the Distress Tolerance Scale [DTS] and Difficulties in Emotion Regulation Scale [DERS]) may help establish the utility of collecting multiple measures on these dimensions and assess whether the AIS captures a useful component of personality that is distinct from the other measures.

Though the relationships between other emotion regulation measures and impulsivity have been examined, no studies as yet have used the AIS in conjunction with delay discounting tasks, or within a cocaine-abusing sample, as the AIS has primarily been used to evaluate cigarette smokers. Exploring the relationship between impulsivity and cognitive-affective measures specific to substance abuse may provide insight into some of the variability seen in treatment outcomes among individuals abusing cocaine, as well as provide support for the appropriateness of utilizing ACT as a relatively novel targeted treatment for cocaine use disorder.

Current Study

This project had three aims. First, to compare the effectiveness of two well-established equations for modelling temporal discounting, AUC and Mazur's *k*, in a cocaine abusing population. Given the highly skewed nature of delay discounting in this population (Stotts et al., 2015; Washio et al., 2011), log-transformed models of both equations were included. It was hypothesized that the log-transformed model of Mazur's *k* equation would provide the best fit for the reward discounting observed in this sample. The second aim of this study was an exploratory factor analysis seeking to determine whether the AIS captures a unique personality characteristic distinct from either emotion regulation or distress tolerance. It was hypothesized that overlap between subscales may contribute to the existence of latent factors between measures. Finally, the third aim was an expansion upon the exploratory analysis, seeking to assess the relationship between these measures, potential latent factors, and delay discounting. It was hypothesized that steeper rates of temporal discounting would correspond to high avoidance/inflexibility, consistent with dominant trends in the literature surrounding distress tolerance and emotion regulation.

CHAPTER 3

METHODS

Ongoing Clinical Trial

Data were collected through the Developing Adaptive Interventions for Cocaine Cessation and Relapse Prevention; Using Event-Related Potentials to Predict Treatment Outcomes in Cocaine Use Disorder study in the Center for Neurobehavioral Research on Addiction at the University of Texas Health Science Center. Participants were 68 treatment-seeking cocaine users between the ages of 18-65, who met DSM-V criteria for either moderate or severe cocaine use disorder (APA, 2013). In addition to meeting DSM-V criteria, participants were required to provide a positive benzoylecgonine urine sample to verify cocaine use. Participants were excluded from the study if they met DSM-V criteria for bipolar disorder, psychosis, endorsed active suicidal ideation, or met criteria for any substance use disorder other than nicotine, cannabis, or alcohol abuse within the past month. The data reflect the baseline measures collected prior to the start of treatment.

Delay Discounting Procedures

The delay discounting task used in this experiment was computer-based and consisted of a titrating number of items scaling to participant choices, with the immediate reward amount varying from $5 to $995 and a delayed reward amount of $1000, at delays of 1 day, 1 week, 1 month, 6 months, 1 year, 5 years, and 25 years. Participants were informed that they would not be receiving real money but instructed to make decisions as though they would receive their selections. This flexible reward scaling system provides more sensitive responses than other methods and facilitates a systematicity check to account for random or nonsensical responses. Data was considered nonsystematic if indifference points at longer delays were 20% higher than indifference points at shorter delays, or if the indifference point at the shortest delay was higher than the indifference point at the longest delay. Four participants were removed from the final data set due to nonsystematic data, resulting in a sample size of 64 participants for the current study.

Self Report Measures

At baseline, participants completed a series of computer-based questionnaires including the AIS, the DTS, and the DERS. The AIS (Gifford et al., 2004) was used to assess participant experiential avoidance and psychological inflexibility, cognitive-affective measures specific to Acceptance and Commitment Therapy. The DTS (Simons & Gaher, 2005) and DERS (Gratz & Roemer, 2004) were collected to assess self-reported distress tolerance and emotion regulation, respectively. These measures were of particular interest in comparison to the AIS, as these measures have been used to capture similar characteristics within the scope of addiction research. Demographic information was collected using the Structured Clinical Interview for the DSM-V (SCID; First et al., 2015).

Avoidance and Inflexibility Scale

The AIS (Gifford et al., 2004) is an index of experiential avoidance and psychological inflexibility specifically tailored to measure these dimensions in relation to substance abuse (Farris et al., 2015). The AIS is a 13-item measure with two subscales: thoughts and feelings (9 items), and somatic sensations (4 items; Farris et al., 2015). Response values range from 1-5 with 1 being “not at all” and 5 being “very likely.” The AIS total score was derived from the sum of all items, and subscale scores from the sum of each respective subscale item, with higher scores indicating higher degrees of avoidance and inflexibility.

Distress Tolerance and Difficulties in Emotion Regulation Scales

The DTS is comprised of 15 items and four subscales: tolerance, absorption, appraisal, and regulation. Response values range from 1-5 with 1 being “strongly agree” and 5 being “strongly disagree.” The total score reflects the higher-order distress tolerance, or the interaction between one's own perception of personal ability to tolerate distress and the demonstrated ability to tolerate distress. The higher order DTS score was determined by calculating the mean of the four subscales (Simons & Gaher, 2005), with higher scores indicating lower distress tolerance.

The DERS is a 36-item measure with six subscales: nonacceptance of emotional response, difficulty engaging in goal-directed behavior, impulse control difficulties, lack of emotional awareness, limited access to emotion regulation strategies, and lack of emotional clarity. Response values range from 1-5 with 1 being "almost never" and 5 being "almost always." The total DERS score was determined by the sum of the 6 subscales (Gratz & Roemer, 2004), with higher scores indicating lower ability to regulate emotions.

Analysis Procedures

Delay Discounting

Delay discounting was assessed using two methods commonly utilized in the literature, AUC and Mazur's *k*. The first delay discounting model was created using the AUC method. AUC is calculated by plotting indifference points (D) on the x-axis and the respective values (V) on the y-axis. Using the formula AUC = $(D_2 - D_1)((V_1 + V_2)/2)$, areas for specific sections of the discounting curve can be measured (Myerson et al., 2001). Adding the calculated area for each section results in a value between 0 to 1, the total AUC, with lower total AUC equating to greater rates of reward discounting. One strength of this method is that the indifference points are derived directly from the data and distributed normally, but literature on steep discounting populations indicates that this method may not best reflect a highly skewed data set (Yoon et al., 2017). The second delay discounting model was created by fitting indifference points to a hyperbolic function using Mazur's *k* equation, $V=A/(1+kD)$ (Mazur, 1987). This equation describes how the value (V) of the reward amount (A) decreases as the delay (D) increases, and the free parameter k describes the rate of discounting, with higher k values equating to steeper reward discounting. Previous work comparing AUC to Mazur's k in the scope of addiction research indicates that this hyperbolic function may be better suited for use with typically highly skewed samples than is traditional AUC (Yoon et al, 2017). Indifference points were fit to both equations using GraphPad Prism 6 (GraphPad Software, San Diego, CA). Additionally, log transformations were performed using both equations. Though log transformation is a popular technique used to normalize data, this technique may alter or misrepresent trends within typically highly skewed samples (Feng et al., 2014). As log transformation is still one of the most popularly utilized methods of normalizing skewed data, and there is support in the literature for use of a validated method of log-transformed AUC to address skewness in temporal discounting data (Borges et al., 2016), this method was also analyzed.

Exploratory Factor Analysis

An exploratory factor analysis was conducted in SPSS (IBM Software, Armonk, NY) using the AIS, DTS, and DERS measures to explore commonalities in emotion regulation characteristics between these measures. Due to the limited sample size, the analysis was conducted using a four-factor solution, consistent with the literature recommendations on exploratory factor analyses (Mundfrom et al., 2005).

Delay Discounting and Cognitive-Affective Measures

Though the exploratory factors strongly aligned with the DERS, DTS, and AIS scales, the exploratory factors, measure scores, and measure subscores were all analyzed in relation to each measure of delay discounting for thoroughness. Spearman and Pearson correlations were conducted on non-normal and log-transformed normalized data, respectively, in addition to a series of linear regressions, to determine the strength of the relationships and identify patterns between each measure. Demographic variables that have been shown to affect rates of delay discounting, including age, sex, race, and years of education were controlled.

CHAPTER 4

RESULTS

Delay Discounting Models

The first component of this project compared two of the most used equations for modelling temporal discounting in substance users. Temporal discounting indifference points were calculated using Area Under the Curve (AUC), log-transformed AUC, and Mazur's *k* and log-transformed *k* model. Consistent with previous work, a strong negative linear relationship was observed between AUC and log-*k* values, as well as AUClog and log-*k* values. Distributions for AUC, *k* and log-*k* were highly skewed, D(63) = 2.95, D(63) = 7.86, and D(63) = 1.31, respectively. AUClog was evenly distributed D(63) = -.27.

Figure 1
AUC Model

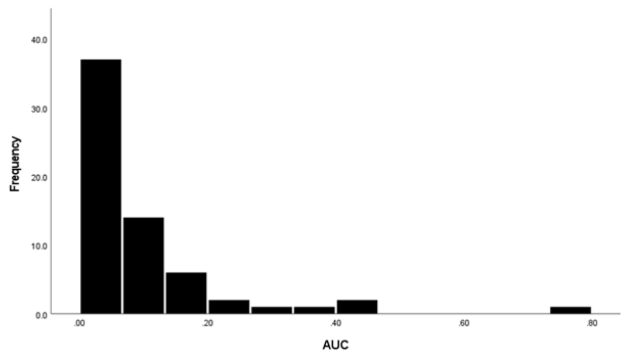


Figure 2
Mazur's k Model

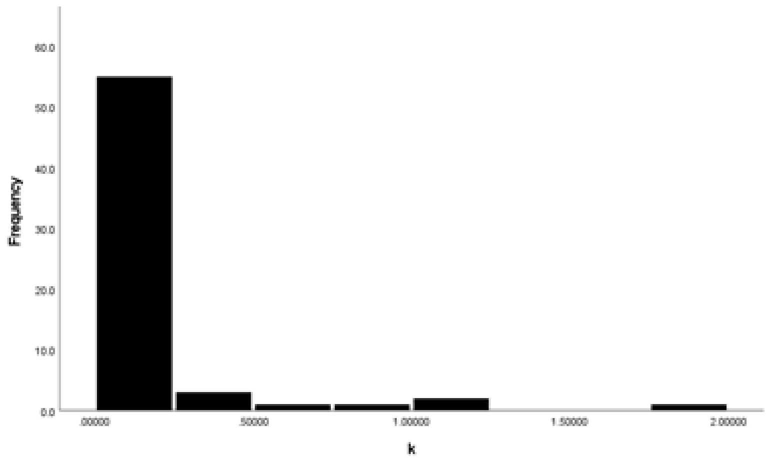


Figure 3
AUC log Model

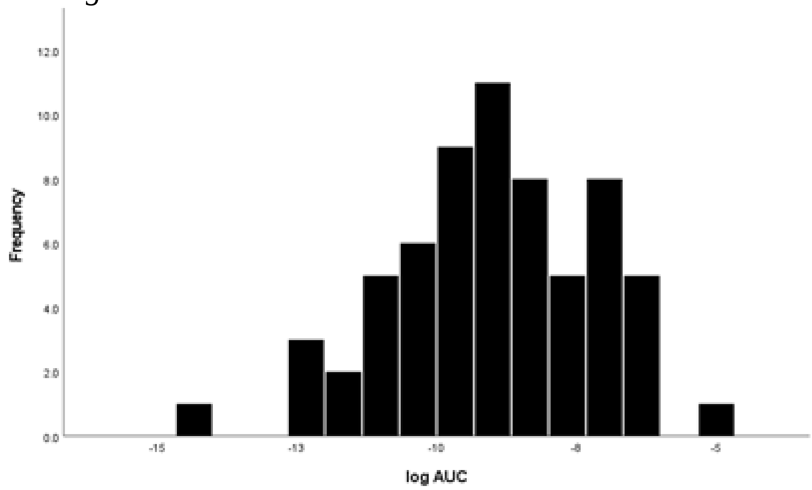
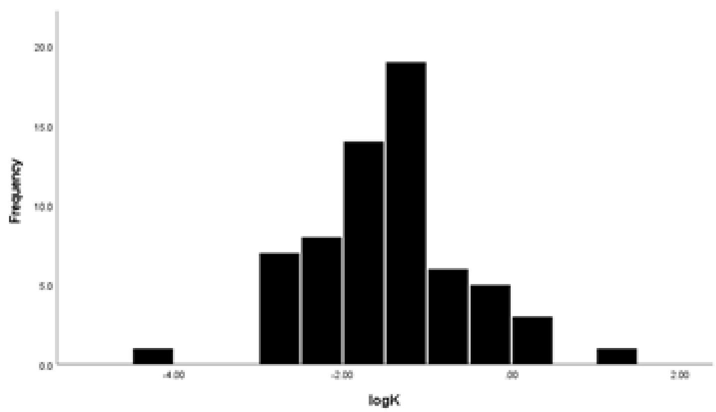


Figure 4
Mazur's k log Model



Cognitive-affective Analysis

An exploratory factor analysis was conducted using items from the DTS, DERS, and AIS scales, in which total scores as well as subscores were analyzed (see Table 1).

Table 1
Baseline Demographics and Measure Scores

Characteristic	**Total (N = 64) %**
Sex	
Female	20.3(13)
Race	
African-American	75(48)
White	15.6(10)
Other/not spec	9.4(6)
Ethnicity	
Not Hispanic	93.0(40)

	Mean(SD)
Age	50(7.7)
Education (years)	12.73(1.5)
AIS Total Score	48.45(11.19)
AIS Affective Subscore	34.89(7.57)
AIS Sensation Subscore	13.56(5)
DTS Total Score	2.84(0.96)
DTS Tolerance Subscore	2.76(1.20)
DTS Absorption Subscore	3.07(1.3)
DTS Appraisal Subscore	3.16(0.98)
DTS Regulation Subscore	2.35(1.09)
DERS Total Score	80.38(21.01)
DERS Nonacceptance Subscore	12.73(5.38)
DERS Goal-directed Subscore	12.56(3.92)
DERS Impulse Control Subscore	12.14(4.71)
DERS Emotional Awareness Subscore	16.91(4.99)
DERS Emotion Regulation Subscore	15.81(5.99)
DERS Emotional Clarity Subscore	10.22(3.87)

Note: AIS = Avoidance and Inflexibility Scale; DERS = Difficulties in Emotion Regulation Scale; DTS = Distress Tolerance Scale.

One factor was dropped due to insufficient components, resulting in a final three factor solution, corresponding to the three measures explored. To reduce multicollinearity within the model, items with a correlation coefficient greater than or equal to .8 were removed. Additionally, items corresponding to 3 or more factors were removed. A total of 8 items were removed across measures, though it is important to note that the determinant remained below the desired cutoff of <.001. Both varimax and direct oblimin rotations were considered, with the varimax rotation chosen for further analysis (see Table 2).

Table 2

Factor loadings based on a principle components analysis with a varimax rotation for 48 items from the AIS, DTS, and DERS (N=64)

Items	Factor			
AIS	**1**	**2**	**3**	**4**
How likely is it that these thoughts will lead you to use?				0.589565
How much are you struggling to control these thoughts?				0.715102
Do you need to reduce how often you have these thoughts in order not to use?				0.594886
Do you need to reduce the intensity of these thoughts in order not to use?				0.695637
How important is getting rid of these feelings?				0.677862
How likely is it that these feelings will lead you to use?				0.760942
How much are you struggling to control these feelings?				0.802467
Do you need to reduce how often you have these feelings in order not to use?				0.759712
How likely is it that these bodily sensations will lead you to use?				0.462742
DERS	**1**	**2**	**3**	**4**
I pay attention to how I feel. (reverse scored)			0.571354	
I experience my emotions as overwhelming and out of control.	0.49186	-0.45052		
I have difficulty making sense out of my feelings.	0.510576			
I am attentive to my feelings. (reverse scored)			0.476206	
I am confused about how I feel.	0.560411			
When I'm upset, I acknowledge my emotions. (reverse scored)			0.446093	
When I'm upset, I become angry with myself for feeling that way.	0.780613			
When I'm upset, I become embarrassed for feeling that way.	0.721765			
When I'm upset, I become out of control.			0.543834	
When I'm upset, I believe that my feelings are valid and important. (reverse scored)	0.819457			
When I'm upset, I have difficulty focusing on other things.				-0.44347
When I'm upset, I feel out of control.	0.516809			
When I'm upset, I can still get things done. (reverse scored)			0.558763	
When I'm upset, I feel ashamed with myself for feeling that way.			-0.73164	
I'll do anything to stop feeling distressed or upset.	0.776351			
When I'm upset, I feel like I am weak.			0.731637	
When I'm upset, I feel like I can remain in control of my behaviors. (reverse scored)	0.512367			
When I'm upset, I feel guilty for feeling that way.			0.40042	
When I'm upset, I become irritated with myself for feeling that way.	0.432011		0.554406	
When I'm upset, I believe that there is nothing I can do to make myself feel better.	0.780054			
When I'm upset, I start to feel very bad about myself.	0.770335			
When I'm upset, I lose control over my behaviors.			0.518629	
When I'm upset, I have difficulty thinking about anything else.			0.72041	
When I'm upset, I take time to figure out how I'm really feeling. (reverse scored)	0.566494			
When I'm upset, I believe that wallowing in it is all I can do.			0.432486	
DTS	**1**	**2**	**3**	**4**
Feeling distressed or upset is unbearable to me.		-0.40803	0.41943	
When I feel distressed or upset, all I can think about is how bad I feel.		0.712785		
I can't handle feeling distressed or upset.	-0.48307	0.64831		
My feelings of distress are so intense that they completely take over.		0.60517		
There's nothing worse than feeling distressed or upset.		0.608513		
When I feel distressed or upset, I cannot help but concentrate on how bad the distress actually		0.713476		
My feelings of distress or being upset are not acceptable.		0.517316		
I'll do anything to avoid feeling distressed or upset.		0.658588		
Other people seem to be able to tolerate feeling distressed or upset better than I can.		0.662422		
Being distressed or upset is always a major ordeal for me.		0.77488		
I am ashamed of myself when I feel distressed or upset.	-0.42208	0.605966		
My feelings of distress or being upset scare me.	-0.53	0.528758		
I'll do anything to stop feeling distressed or upset.		0.531208		
When I feel distressed or upset, I must do something about it immediately.		0.631159		

Note. Factor loadings < .4 are suppressed.

A three-factor solution was analyzed for this sample. The first factor was comprised of 13 items from the DERS, the second factor was comprised of 13 items from the DTS, and the final factor was comprised of 9 items from the AIS (See Table 2). Each factor was comprised entirely of separate scales. Pearson correlations were conducted between factors and scale total scores (see Table 3). Strong positive correlations were observed between factor 1 (emotion regulation) and the DERS total score (r = .73, p < .001), as well as the DERS nonacceptance subscale (r = .899, p < .001). Strong positive correlations were also observed between factor 2 (distress tolerance) and the DTS total score (r = .91, p < .001), as well as between factor 3 (craving regulation) and the AIS total score (r = .89, p < .001).

Table 3
Factor and Total Score Correlations

		DERS Total Score	DTS Total Score	AIS Total Score
Factor 1 (Emotion Regulation)	*r*	.730**	-.316*	.269*
	p	0.000	0.011	0.032
	N	64	64	64
Factor 2 (Distress Tolerance)	*r*	-.357**	.910**	-0.174
	p	0.004	0.000	0.170
	N	64	64	64
Factor 3 (Craving Regulation)	*r*	0.039	-0.089	.887**
	p	0.761	0.487	0.000
	N	64	64	64
DERS Total Score	*r*		-.652**	.269*
	p		0.000	0.031
	N		64	64
DTS Total Score	*r*	-.652**		-.315*
	p	0.000		0.011
	N	64		64
AIS Total Score	*r*	.269*	-.315*	
	p	0.031	0.011	
	N	64	64	

A moderate correlation was observed between factor 1 and the DERS regulation subscale (r = .677, p < .001). AIS affective, sensation, and total scores were negatively correlated (r*'s* = -.402, -.417, -.458, all p*'s* <.001) with DTS regulation. AIS sensation and total scores were mildly positively correlated (*r's* = .356, .269, all *p's* < .05) to DERS total score. DERS and DTS total scores were moderately negatively correlated (r = -.652, p <.001). A strong negative correlation was observed between DERS total score and DTS absorption subscore (r = -.711, p <.001) and DTS appraisal (r =-.719, p <.001).

Delay discounting and Cognitive-affective Measures

Pearson correlations and a series of linear regressions were conducted to explore the directionality of the relationship between factors, DTS, DERS, AIS, subscale scores and delay discounting (see Table 3). Within this sample, there were no significant observed relationships between rates of delay discounting and AIS, DTS, or exploratory factors, with the exception of a moderate correlation (r = .311, p = .012) between the DERS impulse control subscale and AUC (see Table 4). Factor 1 aligned with emotional control, factor 2 aligned with distress tolerance, and factor 3 aligned with craving regulation.

Table 4
Delay Discounting and Total Score Correlations

		k	logk	auc	AUClog
k	*r*		.454**	-0.034	-.388**
	p		0.000	0.787	0.002
	N		64	64	64
logk	*r*	.454**		0.040	-.825**
	p	0.000		0.756	0.000
	N	64		64	64
auc	*r*	-0.034	0.040		-0.110
	p	0.787	0.756		0.385
	N	64	64		64
AUClog	*r*	-.388**	-.825**	-0.110	
	p	0.002	0.000	0.385	
	N	64	64	64	
AIS affective	*r*	0.039	0.046	0.032	-0.178
	p	0.762	0.715	0.800	0.160
	N	64	64	64	64
AIS sensation	*r*	0.035	-0.023	0.084	-0.031
	p	0.787	0.855	0.511	0.808
	N	64	64	64	64
DTS tolerance	*r*	0.023	0.077	-0.028	-0.058
	p	0.855	0.547	0.823	0.649
	N	64	64	64	64
DTS absorption	*r*	0.014	-0.020	-0.153	-0.077
	p	0.915	0.878	0.227	0.543
	N	64	64	64	64
DTS appraisal	*r*	-0.009	0.114	-0.154	-0.098
	p	0.942	0.372	0.224	0.443
	N	64	64	64	64
DTS regulation	*r*	-0.037	-0.056	0.042	0.088
	p	0.773	0.658	0.740	0.488
	N	64	64	64	64
DERS nonacceptance	*r*	-0.014	-0.025	0.178	0.073
	p	0.913	0.844	0.160	0.566
	N	64	64	64	64
DERS goal-directed	*r*	-0.022	-0.035	0.044	0.059
	p	0.861	0.785	0.729	0.641
	N	64	64	64	64
DERS impulse control	*r*	-0.101	-0.138	.311*	0.177
	p	0.429	0.276	0.012	0.162
	N	64	64	64	64
DERS awareness	*r*	0.104	-0.055	0.084	0.118
	p	0.413	0.664	0.507	0.354
	N	64	64	64	64
DERS emotion regulation	*r*	0.067	-0.105	0.182	0.130
	p	0.600	0.410	0.149	0.304
	N	64	64	64	64
DERS emotional clarity	*r*	-0.022	-0.091	0.100	0.054
	p	0.862	0.476	0.433	0.674
	N	64	64	64	64

Though none of the linear regressions conducted showed significant relationships in this sample, a linear regression conducted with AUC values serving as the independent variable and DERS total score serving as the dependent variable approached significance (see Table 5). Age, sex, and years of education were controlled.

Table 5
Linear regressions with delay discounting scores serving as the independent variable and cognitive-affective measures (AIS, DTS, DERS) serving as the dependent variable.

AIS	**β**	**SE**	***p*-value**
auc	0.033	8.077	0.801
AUClog	-0.356	1.423	0.123
logk	-0.291	2.816	0.218
k	0.036	0.539	0.800
DERS	**β**	**SE**	***p*-value**
auc	0.242	14.851	0.060
AUClog	0.248	2.616	0.271
logk	0.050	5.177	0.829
k	0.091	0.990	0.517
DTS	**β**	**SE**	***p*-value**
auc	-0.096	0.706	0.465
AUClog	-0.083	0.124	0.721
logk	-0.022	0.246	0.926
k	-0.026	0.047	0.857

CHAPTER 5

DISCUSSION

Interpretation of Results

Comparison of Delay Discounting Models

The first aim of this project sought to compare multiple methods of delay discounting modelling in a cocaine-addicted sample. Delay discounting rates were modelled using two equations, AUC and Mazur's *k*, as well as log-transformed versions of both methods. High skewness was observed in all analysis methods apart from AUClog, consistent with results from previous work conducted with non-cocaine addicted populations (Yoon et al., 2017; Yoon et al., 2018). While previous work supported the use of log-transformed Mazur's *k* as the best fit for such highly skewed data sets (Yoon et al., 2017; Yoon et al., 2018), results from this project indicate that AUClog may provide equivalent or superior utility. AUClog was the only method that yielded a normalized distribution in this sample, suggesting that assumptions of the standard AUC method (the assumed normalness of distributions) may not be appropriate for typically highly skewed samples such as this.

Within the scope of addiction research, delay discounting has been most widely applied to tobacco users (Bickel et al., 1999; Bickel et al., 2014a, 2014b; Farris et al., 2017; Fillmore, 2003; Reynolds, 2006; Sheffer, et al., 2012; Yoon et al., 2018) and to a lesser extent, alcohol users (Bickel et al., 2001; Bidwell et al., 2013). Though psychostimulants have been used to study the potential for cognitive enhancement in conjunction with delay discounting tasks (Fillmore et al., 2006), the use of delay discounting tasks has only recently expanded to include individuals addicted to psychostimulants (Yoon et al., 2017), and limited work has been conducted on individuals with moderate-to-severe cocaine use disorder specifically (Coffey et al., 2003; Heil et al., 2006). Given the relatively small bank of literature to draw from when studying delay discounting in relation to cocaine addiction, it may be of benefit to continue to assess delay discounting using multiple models when working with this population.

Exploratory Factor Analysis and Cognitive-Affective Scales

The second aim sought to identify potential latent factors between the AIS, DTS, and DERS measures. Results of the exploratory factor analysis suggest that while there may be similarities in characteristics and in the predictive value of clinically relevant outcomes between the cognitive-affective measures of distress tolerance, emotion regulation, and psychological avoidance and inflexibility, each measure encompasses a distinct characteristic. Thus, the alternative hypothesis that the DTS, DERS, and AIS measures capture distinct clinically relevant traits was supported. While there was some overlap between subscales of each measure, the first identified factor aligned cleanly with emotion regulation items, the second with distress tolerance, and the third with the ability to regulate and inhibit craving cues. The independence of these variables may have clinically relevant implications, as treatment methods that are successful with one variable may not be effective on another, despite superficial similarities between affective variables.

Delay Discounting and Cognitive-Affective Measures

Unexpectedly, there were no significant observed relationships between these measures and delay discounting, though delay discounting, distress tolerance, and emotion regulation serve as similarly robust predictors of similar treatment outcomes (Bornovalova, et al., 2011; Daughters et al., 2005; Kollins, 2003; Stanger et al., 2012; Stevens et al., 2014; Stotts et al., 2015). This finding suggests that reward sensitivity, as captured by delay discounting, may represent the existence of a separate variable that should be specifically targeted during treatment, as techniques that influence affective variables that contribute to similar poor outcomes may not be effective.

Limitations

This project had several limitations, with one of the most meaningful being the small sample size. Data for this project were collected from an ongoing clinical trial, and due to time limitations, a more appropriate sample size to conduct an exploratory factor analysis for this many variables was not reached (de Winter et al., 2009). Due to this limitation, the efficacy of related statistical analyses may have been diminished. Another limitation of this project was the inability to directly analyze these findings with typical treatment outcome measures such as relapse, abstinence duration, or treatment compliance, due to the limited sample size as well as issues related to unblinding of the clinical trial, as the data were collected within the context of an ongoing project. Additionally, demographic differences including sex, race, and education, were not explored due to the lack of heterogeneity seen in this sample. A larger, more diverse sample may show trends that were not observed in this project.

Suggestions for Future Research

Further work exploring the first aim of this project, comparison of delay discounting techniques on a cocaine addicted sample, may expand by comparing models for differing task types (e.g., money-to-money and drug-to-money tasks) from this population to other addicted populations (Yoon et al., 2018). The results from this project were consistent with dominant trends in the literature surrounding steep discounting in addicted populations, and it would be of merit to determine whether cocaine users demonstrate similar results on a drug-to-money discounting task in comparison to a different psychostimulant abusing population, such as methamphetamine users.

The exploratory factor analysis conducted in this project supports the distinction between emotion regulation, distress tolerance, and a factor related to the ability to inhibit or regulate craving cues. Further exploratory work on this topic may yield different results, particularly if using a larger sample size and more diverse measures, such as craving, personality-trait impulsivity, compulsiveness, anxiety, anhedonia, and depression scales. The utilization of more diverse measures may yield better insight into the potential latent factors between clinically relevant measures.

REFERENCES

Aldao A, Nolen-Hoeksema S, Schweizer S. (2010). Emotion-regulation strategies across psychopathology: A meta-analytic review. *Clin Psychol Rev, 30* (2):217-37.

Banducci AN, Bujarski SJ, Bonn-Miller MO, Patel A, Connolly KM. (2016). The impact of intolerance of emotional distress and uncertainty on veterans with co-occurring PTSD and substance use disorders. *Journal of Anxiety Disorders, 41,* 73-81.

Bernstein, A., Zvolensky, M.J., Vujanovic, A.A., Moos, R. (2009). Anxiety sensitivity, distress tolerance, and discomfort intolerance: A hierarchical model of affect sensitivity and tolerance. *Behavior Therapy*, *40*, 291–301.

Bickel, W.K., Johnson, M.W., Koffarnus, M.N., MacKillop, J., Murphy, J.G. (2014a). The behavioral economics of substance use disorders: reinforcement pathologies and their repair. *Annu. Rev. Clin. Psychol.*, *10*, 641–677.

Bickel, W.K., Koffarnus, M.N., Moody, L., Wilson, A.G. (2014b). The behavioral- and neuro-economic process of temporal discounting: a candidate behavioral marker of addiction. *Neuropharmacology, 76*, 518–527.

Bickel WK, Marsch LA. (2001). Toward a behavioral economic understanding of drug dependence: delay discounting processes. *Addiction*. *96*, 73–86.

Bickel, W.K., Odum, A.L., Madden, G.J. (1999). Impulsivity and cigarette smoking: delay discounting in current, never, and ex-smokers. *Psychopharmacology, 146*, 447–454.

Bidwell, L.C., MacKillop, J., Murphy, J.G., Grenga, A., Swift, R.M., McGeary, J.E., (2013). Biphasic effects of alcohol on delay and probability discounting. *Exp. Clin. Psychopharmacol. 21*, 214–221.

Borges, Allison & Kuang, Jinyi & Milhorn, Hannah & Yi, Richard. (2016). An alternative approach to calculating Area-Under-the-Curve (AUC) in delay discounting research: ALTERNATIVE TO AUC. *Journal of the Experimental Analysis of Behavior, 106.*

Bornovalova , M. A., Gratz, K. L., Daughters, S. B., Hunt, E. D., & Lejuez , C. W. (2011). Initial RCT of a distress tolerance treatment for individuals with substance use disorders. *Drug and Alcohol Dependence, 122*(1-2), 70-76.

Chung S.-H, Herrnstein R.J. (1967). Choice and delay of reinforcement. *Journal of the Experimental Analysis of Behavior, 10*, 67–74.

Coffey, S. F., Gudleski, G. D., Saladin, M. E., & Brady, K. T. (2003). Impulsivity and rapid discounting of delayed hypothetical rewards in cocaine-dependent individuals. *Experimental and Clinical Psychopharmacology, 11*(1), 18–25.

Curtin, J. J., McCarthy, D. E., Piper, M. E., & Baker, T. B. (2006). Implicit and Explicit Drug Motivational Processes: A Model of Boundary Conditions. *In R. W. Wiers & A. W. Stacy (Eds.), Handbook of implicit cognition and addiction* (p. 233–250).

Daughters, S. B., Lejuez , C. W., Kahler, C. W., Strong, D. R., & Brown, R. A. (2005). Psychological Distress Tolerance and Duration of Most Recent Abstinence

Attempt Among Residential Treatment-Seeking Substance Abusers. *Psychology of Addictive Behaviors*, 208-211.

J. C. F. de Winter, D. Dodou & P. A. Wieringa (2009) Exploratory Factor Analysis With Small Sample Sizes. *Multivariate Behavioral Research*, *44*:2, 147-181.

Dierst-Davies, R., Reback, C. J., Peck, J. A., Nuño, M., Kamien, J. B., & Amass, L. (2011). Delay-discounting among homeless, out-of-treatment, substance-dependent men who have sex with men. *The American Journal of Drug and Alcohol Abuse*, 93-97.

Ding, W., Sun, J., Sun, Y., Chen, X., Zhou, Y., Zhuang, Z., Li, L., Zhang, Y., Xu, J., & Du, Y. (2014) Trait impulsivity and impaired prefrontal impulse inhibition function in adolescents with internet gaming addiction revealed by a Go/No-Go fMRI study. *Behav Brain Funct*, *10*, 20.

Engelmann JM, Versace F, Gewirtz JC, Cinciripini PM. (2016). Individual differences in brain responses to cigarette-related cues and pleasant stimuli in young smokers. *Drug Alcohol Depend*., *163*:229-235.

Estévez, A., Jáuregui, P., Sánchez-Marcos, I., López-González, H., & Griffiths, M. D. (2017). Attachment and emotion regulation in substance addictions and behavioral addictions. *Journal of Behavioral Addictions*, *6*(4), 534-544.

Farris, S. G., Zvolensky, M. J., DiBello, A. M., & Schmidt, N. B. (2015). Validation of the avoidance and inflexibility scale (AIS) among treatment-seeking smokers. *Psychological Assessment*, 467-477.

Farris, S. G., Zvolensky, M. J., & Schmidt, N. B. (2014;2015). Smoking-specific experiential avoidance cognition: Explanatory relevance to pre- and post-cessation nicotine withdrawal, craving, and negative affect. *Addictive Behaviors*, 58-64.

Farris, S. G., Aston, E. R., Abrantes, A. M., & Zvolensky, M. J. (2017). Tobacco demand, delay discounting, and smoking topography among smokers with and without psychopathology, *Drug and Alcohol Dependence, 179,* 247-253.

Feng, C., Wang, H., Lu, N., Chen, T., He, H., Lu, Y., & Tu, X. M. (2014). Log-transformation and its implications for data analysis. *Shanghai archives of psychiatry*, *26*(2), 105–109.

Fillmore, MT. (2003). Drug abuse as a problem of impaired control: current approaches and findings. *Behavioral & Cognitive Neuroscience Reviews*, 2, 179-197.

Fillmore MT, Rush CR, & Hayes L. (2006). Acute effects of cocaine in two models of inhibitory control: implications of non-linear dose effects. *Addiction, 101*(9), 1323–1332.

Fillmore, M. T., & Weafer, J. (2013). Behavioral inhibition and addiction. *In J. MacKillop & H. de Wit (Eds.), The Wiley-Blackwell handbook of addiction psychopharmacology* (p. 135–164). Wiley Blackwell.

First MB, Williams JBW, Karg RS, Spitzer RL: Structured Clinical Interview for DSM-5—Research Version (SCID-5 for DSM-5, Research Version; SCID-5-RV). Arlington, VA, American Psychiatric Association, 2015

Flagel SB, Watson SJ, Akil H, Robinson TE. (2008). Individual differences in the attribution of incentive salience to a reward-related cue: Influence on cocaine sensitization. *Behav Brain Res., 186*(1):48-56.

Gamito P, Oliveira J, Baptista A, Morais D, Lopes P, Rosa P, Santos N, & Brito R. (2014). Eliciting Nicotine Craving with Virtual Craving Cues. *Cyberpsychology, Behavior, and Social Networking, 17*(8), 556-561.

Gifford EV, Kohlenberg BS, Hayes SC, Pierson HM, Piasecki MP, Antonuccio DO, Palm KM. (2011). Does acceptance and relationship focused behavior therapy contribute to bupropion outcomes? A randomized controlled trial of functional analytic psychotherapy and acceptance and commitment therapy for smoking cessation. *Behavior Therapy, 42*(4), 700–715.

Gifford EV, Kohlenberg BS, Hayes SC, Antonuccio DO, Piasecki MM, Rasmussen-Hall ML, & Palm KM. (2004). Acceptance-based treatment for smoking cessation. *Behavior Therapy*, *35(*4), 689-705.

Goodman, A. (2008). Neurobiology of addiction: An integrative review. *Biochemical Pharmacology*. *75*(1), 266-322.

Gratz, K. L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the difficulties in emotion regulation scale. *Journal of Psychopathology and Behavioral Assessment. 26*(1), 41–54.

Griffiths, M. D. (2005). A components model of addiction within a biopsychosocial framework. *Journal of Sustance Use, 10*(4), 191–197.

Hayes, S. C., Strosahl, K., Wilson, K. G., Bissett, R. T., Pistorello, J., Toarmino, D., .McCurry, S. M. (2004). Measuring experiential avoidance: A preliminary test of a working model. *The Psychological Record. 54*, 553–578.

Heil, S. H., Johnson, M. W., Higgins, S. T., & Bickel, W. K. (2006). Delay discounting in currently using and currently abstinent cocaine-dependent outpatients and non-drug-using matched controls. *Addictive Behaviors*, 1290-1294.

IBM Corp. Released 2020. IBM SPSS Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp

Ilieva, I., & Farah, M. (2013). Enhancement stimulants: perceived motivational and cognitive advantages. *Frontiers in Neuroscience*, *7*, 198.

Kaiser A, Milich R, Lynam DR, Charnigo RJ. (2012). Negative Urgency, Distress Tolerance, and substance abuse among college students. *Addictive Behaviors. 37*(10), 1075-1083.

Kollins, S. H. (2003). Delay discounting is associated with substance use in college students. *Addictive Behaviors. 28*(6), 1167-1173.

Kozak A, Fought A. (2011). Beyond alcohol and drug addiction. Does the negative trait of low distress tolerance have an association with overeating? *Appetite. 57*(3), 578-581.

Lattal K.A. (2010). Delayed reinforcement of operant behavior. *Journal of the Experimental Analysis of Behavior*. *93*, 129–139.

Leventhal, A. M., Brightman, M., Ameringer, K. J., Greenberg, J., Mickens, L., Ray, L. A., Ping, S., Sussman, S. (2010). Anhedonia associated with stimulant use and dependence in a population-based sample of American adults. *Experimental and Clinical Psychopharmacology. 18*(6), 562-569.

Leyro, T.M., Zvolensky, M.J., Bernstein, A. (2010). Distress tolerance and psychopathological symptoms and disorders: A review of the empirical literature among adults. *Psychological Bulletin. 136*, 576–600.

Li, Zhang, Xiao, Nie. (2016). The association of Internet addiction symptoms with impulsiveness, loneliness, novelty seeking and behavioral inhibition system among adults with attention-deficit/hyperactivity disorder (ADHD). *Psychiatry Research. 24*, 357-364.

Lynam, D. R., Whiteside, S. P., Smith, G. T., & Cyders, M. A. (2006). The UPPS-P: Assessing five personality pathways to impulsive behavior. West Lafayette, IN: Purdue University. Unpublished report.

Mendez, I. A., Simon, N. W., Hart, N., Mitchell, M. R., Nation, J. R., Wellman, P. J., & Setlow, B. (2010). Self-administered cocaine causes long-lasting increases in impulsive choice in a delay discounting task. *Behavioral Neuroscience*, 470-477.

MacKillop J., Amlung M.T., & Few L.R. (2011). Delayed reward discounting and addictive behavior: a meta-analysis. *Psychopharmacology*. *216*, 305–321.

Mazur, JE. An adjusting procedure for studying delayed reinforcement. (1987). In: Mazur, JE.Nevin, JA., Rachlin, H., editors. The Effects of Delay and of Intervening Events on Reinforcement Value. Vol. 5. New Jersey: Erlbaum. p. 55-73.

Minami, H., Bloom E. L., Reed, K. M., Hayes, S. C., & Brown, R. A. (2015). The moderating role of experiential avoidance in the relationships between internal distress and smoking behavior during a quit attempt. *Addictive Behaviors*. 400-407.

Mogg, K., Field, M. & Bradley, B.P. (2005). Attentional and approach biases for smoking cues in smokers: an investigation of competing theoretical views of addiction. *Psychopharmacology. 180*, 333–341.

Mundfrom, D. J., Shaw, D. G., & Ke, T. L. (2005) Minimum Sample Size Recommendations for Conducting Factor Analyses. *International Journal of Testing*. 5(2), 159-168.

Myerson, J., Green, L., & Warusawitharana, M. (2001). Area under the curve as a measure of discounting. *Journal of the experimental analysis of behavior. 76*(2), 235–243.

Odum A. L. (2011). Delay discounting: I'm a k, you're a k. Journal of the experimental analysis of behavior, 96(3), 427–439.

Patton JH, Stanford MS, and Barratt ES. (1995). Factor structure of the Barratt impulsiveness scale. *Journal of Clinical Psychology*, *51*, 768-774. PubMed ID 8778124

Perry, J. L., Larson, E. B., German, J. P., Madden, G. J., & Carroll, M. E. (2005). Impulsivity (delay discounting) as a predictor of acquisition of IV cocaine self-administration in female rats. *Psychopharmacology*, 193-201.

Prendergast, M., Podus, D., Finney, J., Greenwell, L., & Roll, J. (2006). Contingency management for treatment of substance use disorders: a meta-analysis. *Addiction, 101*(11), 1546-1560.

Reynolds B. (2006). A review of delay-discounting research with humans: relations to drug use and gambling. *Behav Pharmacol*., *17*(8), 651-67.

Robinson T.E., Berridge K.C. (1993). The neural basis of drug craving: An incentive-sensitization theory of addiction. *Brain Res Rev*., *18*(3), 247-291.

Saunders B.T., Robinson T.E. (2009). A Cocaine Cue Acts as an Incentive Stimulus in Some but not Others: Implications for Addiction. *Biol Psychiatry, 67*(8), 730-736.

Sayegh C.S., Huey S.J., Zara E.J., Jhaveri K. Follow-up treatment effects of contingency

management and motivational interviewing on substance use: A meta-analysis. *Psychology of Addictive Behaviors*, *31*(4), 403-414.

Services, S. A. a. M. H. (2017). *Key substance use and mental health indicators in the United States: Results from the 2016 National Survey on Drug Use and Health*. Retrieved from Rockville, MD.

Simon, N. W., Mendez, I. A., & Setlow, B. (2007). Cocaine exposure causes long-term increases in impulsive choice. *Behavioral Neuroscience,* 543-549.

Simons, J.S., Gaher, R.M. The Distress Tolerance Scale: Development and Validation of a Self-Report Measure. *Motiv Emot* 29, 83–102 (2005). https://doi.org/10.1007/s11031-005-7955-3

Sheffer, C., MacKillop, J., McGeary, J., Landes, R., Carter, L., Yi, R., Jones, B., Christensen, D., Stitzer, M., Jackson, L. and Bickel, W. (2012), Delay Discounting, Locus of Control, and Cognitive Impulsiveness Independently Predict Tobacco Dependence Treatment Outcomes in a Highly Dependent, Lower

Socioeconomic Group of Smokers. *The American Journal on Addictions*. 21, 221-232. doi:10.1111/j.1521-0391.2012.00224.x

Stanger, C. R., Landes, R. D., Jones, B. A., Bickel, W. K., & Budney, A. J. (2012). Delay discounting predicts adolescent substance abuse treatment outcome. *Experimental and Clinical Psychopharmacology*.

Stevens, L., Verdejo-García, A., Goudriaan , A. E., Roeyers , H., Dom, Geert, & Vanderplasschen , W. (2014). Impulsivity as a vulnerability factor for poor addiction treatment outcomes: A review of neurocognitive findings among individuals with substance use disorders. *Journal of Substance Abuse Treatment*.

Stotts, A., Vujanovic, A., Heads, A., & Suchting, R. (2015). The role of avoidance and inflexibility in characterizing response to contingency management for cocaine use disorders: A secondary profile analysis. *Psychology of Addictive Behaviors*, 408-413.

Trafton, J.A., Gifford, E.V. (2011). Biological bases of distress tolerance. In Zvolensky, M.J., Bernstein, A., Vujanovic, A.A. (Eds.). Distress tolerance, New York: Guilford.

Tull, M.T., Berghoff, C.R., Wheeless, L.E., Cohen, R.T., & Gratz, K.L. (2018). PTSD Symptom Severity and Emotion Regulation Strategy Use During Trauma Cue Exposure Among Patients With Substance Use Disorders: Associations With Negative Affect, Craving, and Cortisol Reactivity. *Behavioral Therapy,* 49(1), 57-70.

Versace, F., Kypriotakis, G., Basen-Engquist, K., & Schembre, S.M. (2016). Heterogeneity in brain reactivity to pleasant and food cues: Evidence of sign-tracking in humans. *Soc Cogn Affect Neurosci*. 11(4), 604-611.

Volkow, N.D., Wang, G.-J., Fowler, J.S., Tomasi, D., Telang, F. (2011). Addiction: Beyond dopamine reward circuitry. *Proc Natl Acad Sci*. 108(37), 15037-15042.

Vujanovic, A.A., Wardle, M.C., Bakhshaie, J., Smith, L., Green, C., Lane, S.D., & Schmitz, J. (2018). Distress tolerance: Associations with trauma and substance cue reactivity in low-income, inner-city adults with substance use disorders and posttraumatic stress. *Psychol Addict Behav*. 32(3), 264-276.

Washio, Y., Higgins, S. T., Heil, S. H., McKerchar, T. L., Badger, G. J., Skelly, J. M., & Dantona, R. L. (2011). Delay discounting is associated with treatment response among cocaine-dependent outpatients. Experimental and clinical psychopharmacology, 19(3), 243–248. https://doi.org/10.1037/a0023617

Yager, L.M., & Robinson, T.E. (2013). A classically conditioned cocaine cue acquires greater control over motivated behavior in rats prone to attribute incentive salience to a food cue. *Psychopharmacology* (Berl). 226(2), 217-228.

Yoon, J., De La Garza II, R., Newton, T., Suchting, R., Weaver, M., Brown, G., Omar, Y., & Haliwa, I. (2017). A Comparison of Mazur’s k and Area Under the Curve for Describing Steep Discounters. *The Psychological Record*, 67(3), 355–363.

Yoon, J.H., Weaver, M.T., De La Garza, R. 2nd, Suchting, R., Nerumalla, C.S., Omar, Y., Brown, G.S., Haliwa, I., & Newton, T.F. (2018). Comparison of three measurement models of discounting among individuals with methamphetamine use disorder. *Am J Addict*. doi: 10.1111/ajad.12761. Epub ahead of print. PMID: 30024076.

Zhang, B., Lin, P., Shi, H., Öngür, D., Auerbach, R. P., & Wang, X. (2016). Mapping anhedonia-specific dysfunction in a transdiagnostic approach: An ALE meta-analysis. *Brain Imaging and Behavior*, 10(3), 920-939.

Zvolensky, M.J., Vujanovic, A.A., Bernstein, A., & Leyro, T. (2010). Distress Tolerance: Theory, Measurement, and Relations to Psychopathology. *Current Directions in Psychological Science*. 19(6), 406-410.

APPENDIX A: SURVEYS

AIS

Directions: Below are three sections. In each section you will find a statement followed by a list of questions. Please rate your response to each question by circling the appropriate number on the scale next to the question. There are no right or wrong answers.

Section One

Sometimes people have thoughts that encourage them to use, for example, "I need a hit!" or "I wish I could use right now!"

1. How likely is it that these thoughts will lead you to use?

Not at all	**A little**	**Somewhat**	**Considerably**	**Very likely**
1	2	3	4	5

2. How much are you struggling to control these thoughts?

Not at all	**A little**	**Somewhat**	**Considerably**	**Very likely**
1	2	3	4	5

3. Do you need to reduce <u>how often</u> you have these thoughts in order not to use?

Not at all	**A little**	**Somewhat**	**Considerably**	**Extensively**
1	2	3	4	5

4. Do you need to reduce <u>the intensity</u> of these thoughts in order not to use?

Not at all	**A little**	**Somewhat**	**Considerably**	**Extensively**
1	2	3	4	5

Section Two

Sometimes people have feelings that encourage them to use, for example, they may really <u>feel</u> like using, and/or they may have feelings such as stress, enjoyment, fatigue, boredom, satisfaction, depressed mood etc. that encourage them to use.

5. How important is getting rid of these feelings?

Not at all	A little	Somewhat	Considerably	Very important
1	2	3	4	5

6. How likely is it that these feelings will lead you to use?

Not at all	A little	Somewhat	Considerably	Very likely
1	2	3	4	5

7. How much are you struggling to control these feelings?

Not at all	A little	Somewhat	Considerably	Very much
1	2	3	4	5

8. Do you need to reduce <u>how often</u> you have these feelings in order to not use?

Not at all	A little	Somewhat	Considerably	Extensively
1	2	3	4	5

9. Do you need to reduce <u>the intensity</u> of these feelings in order to not use?

Not at all	A little	Somewhat	Considerably	Extensively
1	2	3	4	5

Section Three

Sometimes people have bodily sensations that encourage them to use. For example, physical cravings or withdrawal symptoms, such as feeling fatigued/tired, hungry, agitated, or having sleep problems.

10. How likely is it that these bodily sensations will lead you to use?

Not at all	A little	Somewhat	Considerably	Very likely
1	2	3	4	5

11. How much are you struggling to get rid of these bodily sensations?

Not at all	A little	Somewhat	Considerably	Very much
1	2	3	4	5

12. Do you need to reduce how often you have these bodily sensations in order not to use?

Not at all	A little	Somewhat	Considerably	Extensively
1	2	3	4	5

13. Do you need to reduce the intensity of these bodily sensations in order not to use?

Not at all	A little	Somewhat	Considerably	Extensively
1	2	3	4	5

DERS

Please indicate how often these items apply to you using the following scale:

1	2	3	4	5
Almost never (0-10%)	Sometimes (11-35%)	About half the time (35-65%)	Most of the time (66-90%)	Almost always (91-100%)

1. _______ I am clear about my feelings.
2. _______ I pay attention to how I feel.
3. _______ I experience my emotions as overwhelming and out of control.
4. _______ I have no idea how I am feeling.
5. _______ I have difficulty making sense out of my feelings.
6. _______ I am attentive to my feelings.
7. _______ I know exactly how I am feeling.
8. _______ I care about what I am feeling.
9. _______ I am confused about how I feel.
10. _______ When I'm upset, I acknowledge my emotions.
11. _______ When I'm upset, I become angry with myself for feeling that way.
12. _______ When I'm upset, I become embarrassed for feeling that way.
13. _______ When I'm upset, I have difficulty getting work done.
14. _______ When I'm upset, I become out of control.
15. _______ When I'm upset, I believe that I will remain that way for a long time.
16. _______ When I'm upset, I believe that I'll end up feeling very depressed.
17. _______ When I'm upset, I believe that my feelings are valid and important.

18. ______ When I'm upset, I have difficulty focusing on other things.

19. ______ When I’m upset, I feel out of control.

20. ______ When I’m upset, I can still get things done.

21. ______ When I’m upset, I feel ashamed with myself for feeling that way.

22. ______ When I’m upset, I know that I can find a way to eventually feel better.

23. ______ When I’m upset, I feel like I am weak.

24. ______ When I’m upset, I feel like I can remain in control of my behaviors.

25. ______ When I’m upset, I feel guilty for feeling that way.

26. ______ When I’m upset, I have difficulty concentrating.

27. ______ When I’m upset, I have difficulty controlling my behaviors.

28. ______ When I’m upset, I believe that there is nothing I can do to make myself feel better.

29. ______ When I’m upset, I become irritated with myself for feeling that way.

30. ______ When I’m upset, I start to feel very bad about myself.

31. ______ When I’m upset, I believe that wallowing in it is all I can do.

32. ______ When I’m upset, I lose control over my behaviors.

33. ______ When I’m upset, I have difficulty thinking about anything else.

34. ______ When I’m upset, I take time to figure out what I’m really feeling.

35. ______ When I’m upset, it takes me a long time to feel better.

36. ______ When I’m upset, my emotions feel overwhelming.

DTS

(Simons & Gaher, 2005)

Directions: Think of times that you feel distressed or upset. Select the item from the menu that best describes your beliefs about feeling distressed or upset.

1. Strongly agree
2. Mildly agree
3. Agree and disagree equally
4. Mildly disagree
5. Strongly disagree

1. Feeling distressed or upset is unbearable to me.
2. When I feel distressed or upset, all I can think about is how bad I feel.
3. I can't handle feeling distressed or upset.
4. My feelings of distress are so intense that they completely take over.
5. There's nothing worse than feeling distressed or upset.
6. I can tolerate being distressed or upset as well as most people.* [reverse scored]
7. My feelings of distress or being upset are not acceptable.
8. I'll do anything to avoid feeling distressed or upset.
9. Other people seem to be able to tolerate feeling distressed or upset better than I can.
10. Being distressed or upset is always a major ordeal for me.
11. I am ashamed of myself when I feel distressed or upset.
12. My feelings of distress or being upset scare me.
13. I'll do anything to stop feeling distressed or upset.
14. When I feel distressed or upset, I must do something about it immediately.
15. When I feel distressed or upset, I cannot help but concentrate on how bad the distress actually feels.